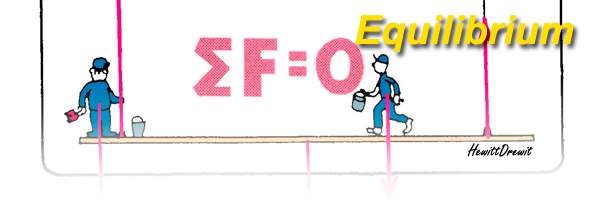
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**Torque Lab 2015**

**Translational and Rotational Equilibrium**

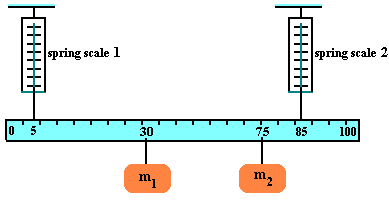
For maintenance on large buildings, scaffolding can be hung on the outside. In order for the scaffolding to support workers, it must be in translational and rotational equilibrium. If two or more forces act on the scaffolding, each can produce a rotation about either end. Scaffolding with uniform mass distribution acts as though all of the mass is concentrated at its center. In translational equilibrium the object is not accelerating; thus, the upward and downward forces are equal. In order to achieve rotational equilibrium, the sum of all the clockwise torques must equal the sum of all the counterclockwise torques as measured from a pivot point. That is, the net torque must be zero. In this lab you will model scaffolding hung from two ropes using a meter stick and spring scales, and use numbers to measure the forces on the scaffolding.

**Goals**What conditions are required for equilibrium when parallel forces act on an object?

Collect and organize data about the forces acting on the scaffolding.

Describe clockwise and counterclockwise torque.

Compare and contrast translational and rotational equilibrium.

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**Materials**

Meter stick

two Buret clamps

two 0-5 N spring scales   
500-g hooked mass

two ring stands 200-g hooked mass

**NOTE: The left spring scale will be considered a pivot point for the purposes of this lab. Therefore, the lever arm will be measured from this point.**

**Variables**

Independent variable: Lever arm  
Dependent variable: Resistance arm

Controlled variable: Meter stick, weights

**Procedure**

**1.** Place the ring stands 80 cm apart.

**2.** Attach a Buret clamp to each of the ring stands.

**3.** Verify that the scales are set to zero before use.

If the scales need to be adjusted, ask your teacher for assistance.

**4.** Hang a spring scale from each Buret clamp attached to a ring stand.

**5.** Hook the meter stick onto the spring scale in such a manner that the 10-cm mark is supported by one hook and the 90-cm mark is supported by the other hook.

**6.** Read each spring scale and record the force in Data Table 1.

**7.** Hang a 500-g mass on the meter stick at the 30-cm mark. This point should be 20-cm from the left scale.

**8.** Read each spring scale and record the force in Data Table 1.

**9.** Hang a 200-g mass on the meter stick at the 70-cm mark. This point should be 60 cm from the left scale.

**10.** Read each spring scale and record the force in Data Table 1.

**Objectives**

■ **Collect and organize data** about the forces acting on the scaffolding.  
■ **Describe** clockwise and counterclockwise torque.  
■ **Compare and contrast** translational and rotational equilibrium.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Data Table 1** | | | | |
| **Object added** | **Distance from left scale (meters)** | **Left Scale Reading** | **Right Scale Reading** | |
| **meter stick** |  |  |  | |
| **500 gram weight** |  |  |  | |
| **200 gram weight** |  |  |  | |
|  |  |  |  | |
| **Data Table 2** | | | | |
| **object added** | **Clockwise Torque** | **Counter-clockwise Torque** | **Lever Arm** | **Force (N)** |
| **meter stick** |  |  |  |  |
| **500 gram weight** |  |  |  |  |
| **200 gram weight** |  |  |  |  |
| **Right Scale** |  |  |  |  |
|  |  |  |  | |
| **Data Table 3** | | | | |
| **object added** | **Clockwise Torque** | **Counter-clockwise Torque** |  | |
| **meter stick** |  |  |  | |
| **500 gram weight** |  |  |  | |
| **200 gram weight** |  |  |  | |
| **Right Scale** |  |  |  | |
| **** |  |  |  | |

**Safety Precautions**

**Use care to avoid dropping masses.**

**Analyze**

**1. Calculate** Find the mass of the meter stick.

**2. Calculate** Find the force, or weight, that results from each object and record it in Data Table 2. For the right scale, read the force it exerts and record it in Data Table 2.

**3.** Using the point where the left scale is attached as a pivot point, identify the forces located elsewhere that cause the scaffold to rotate clockwise or counterclockwise. Mark these in Data Table 2 with an *x*.

**4.** Record the lever arm distance of each force from the pivot point in Data Table 2.

5. Use Numbers. Calculate the torque for each object by multiplying the force and lever arm distance. Record these values in Data Table 3.

**Conclude and Apply**

**1.** Is the system in translational equilibrium? How do you know?

**2.** Draw a free-body diagram of your system, showing all the forces.

**3.** Compare and contrast the sum of the clockwise torques, \_\_c, and the counterclockwise torques, \_\_cc.

**4.** What is the percent difference between \_\_c and \_\_cc?

**Going Further**

Use additional masses at locations of your choice with your teacher’s permission and record your data.